GALATEA

OR

The Future of Darwinism

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TO-DAY AND TO-MORROW

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This I believe :
The ape
of which I wear the shape
tumbled in me—his Hell—
a furry archangel,
and, with the only skill he had,
swung with one pitiful blackpad
into the jungle of my will
desiring, till
with a final stroke
he tore his prison-vesture off, and spoke.
He threw aside, because he willed,
the coat that clamped and killed,
and shall he not assume, if he have striven,
when all is done, investiture in heaven ?

HUMBERT WOLFE—from
Requiem Ernest Benn, Ltd.)

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OR
THE FUTURE OF DARWINISM

It is hardly possible to accept the current Neo-Darwinian views on evolution without experiencing grave doubts concerning the rationality of the Universe. The existing characteristics of all living creatures have arisen, we are told, in a long series of small steps. Each step has given the organism in which it has occurred an advantage over its fellows, so that it has tended, other things being equal, to live longer

and leave more offspring to perpetuate the novelty. Thus the advantageous characters have persisted and been added to and further developed. This is not difficult to understand. If, however, we ask how these new factors, known as mutations, have arisen, we are told that their appearance has no relation whatever to their value. The germinal material in which they arise is virtually independent of the individual that acts as its host. There is no convincing proof that any change which the environment has brought about in an organism can be transmitted to the next generation. No exercise of an existing faculty improves the equipment of the offspring. We cannot at present explain why mutations occur, but we already know a

great deal about the carriage of the hereditary factors in the germ-cells. Every cell contains a nucleus in which are a number of conspicuous rods which have received the name of chromosomes. It has been possible to show that in the germ-cells the chromosomes are the bearers of the hereditary factors. It has even been demonstrated that the hereditary factors are represented in the chromosomes in a definite and constant order, so that the distance between the positions in the chromosome occupied by the bearers of particular characters can be measured. In some species it has been possible to arrange the known hereditary characters into groups and to show that the number of groups is the same as the number of

chromosomes. We must picture each chromosome, then, as a string of beads, each of which represents a hereditary factor, called a gene. If now we ask what is the nature of these bearers of inherited characters, we are told that they are complex chemical substances, which, with the progress of knowledge, we may hope to be able to define accurately in chemical terms. The change which leads to the appearance of a new character, or an alteration in an existing one, occurs in the gene. Some physical accident or molecular instability changes its composition and a new and possibly advantageous feature makes its appearance in the offspring which develops from the altered germ-cell.

This is necessarily a much condensed account of current teaching about evolution. Its essential doctrine is that the germinal material is virtually independent of the rest of the body and hence there can be no direct relationship between the origin of a new characteristic and the environment. The raw material of evolution is the mutable germ-cell, which throws up useful, useless, or positively harmful new characters with complete indifference. Like molten metal, life is capable, if unrestrained, of spreading itself in all directions. Environment, like the mould into which the metal is poured, checks its advance here and permits it there, and so determines the form of the final product.

What conception of the forces at

work in evolution does the theory just summarized imply? The creative activity which proceeds by such methods could hardly be described as rational. Let us try by analogy to picture the course of evolution according to Neo-Darwinism. Imagine a company of people setting out from London and deciding their destinations by opening at random the pages of Bradshaw and taking a ticket for the first town on which their glance alighted. Suppose them to repeat the process on reaching their first destinations and assume that there is a law by which all who are unfortunate enough to hit upon a second town which is not on the same line as the first are forthwith executed. If this process were repeated a number of times, what

would be the result? A comparatively small band of survivors would be scattered around the coasts of Great Britain. If they had been allowed to keep their railway tickets, we should be able to recognize relationships among them. The important family of Great Westerns would all show evidence of having passed through Reading. Some would exhibit common features in their progress as far as Oxford, or even further. Remains would be found of primitive types which had never got beyond Slough, allied to a still surviving but primitive species at Windsor. Two families would be found that had reached Scotland by entirely different routes. Species would be discovered which had advanced and then retrogressed, having returned

almost to London, but still showing traces in dress and accent of a stay in the provinces.

Thus there would be an appearance of orderly progress brought about by the selective action of the environment upon entirely haphazard journeying. This could not, however, be regarded as a rational mode of locomotion. No analogy is perfect, but the parable illustrates the two cardinal features of evolution according to Neo-Darwinism, namely, that mutations are fortuitous, and, that, though they are entirely unrelated in origin to environment, it is solely in relation to environment that they possess value.

II

After this description of the general principles of Neo-Darwinism, it will be helpful to consider a particular instance of their operation. We cannot do better than take as an example the evolution of the human upright posture. The fossil record of man's evolution is fragmentary and in many places entirely missing, but we are greatly helped by the fact that existing monkeys and apes, although not in the direct line of human ancestry, nevertheless preserve many features

which almost certainly characterized our sub-human forbears. Much can therefore be learned from comparative anatomy concerning the probable course of the structural changes accompanying the development of the upright attitude of man. Sir Arthur Keith[1] believes that the first step was the evolution from the monkey of a small anthropoid ape of the type now represented by the gibbon. From this, in the process of time, was derived a large anthropoid, possessing, in general, characteristics shared by the chimpanzee, the orang and the gorilla of to-day. The last phase was the development from this great anthropoid stock of a creature with character-

[1] *British Medical Journal* 1923, 1,451.

istically human lower limbs, a primitive man.

The change from a monkey which walks on all-fours to man who walks erect involved the most profound alterations in every organ of the body. The nervous centres of the brain and spinal cord concerned with balance and progression required adjustment and elaboration. The bones of the spine altered, some fusing together and so giving greater strength and stability. The curves of the spine were changed. The muscles of the spine, 416 in number, were all modified to a varying extent by migration of their points of attachment to bone, and in other ways. The nervous control of of the circulation of the blood required reorganizing to deal with the entirely

new problems in hydrostatics. The breathing apparatus underwent what Sir Arthur Keith calls "a structural revolution". "Ribs, vertebrae, sternum, body wall and spinal muscles", he writes, "diaphragm, pleurae, lungs and heart underwent a simultaneous harmonious adaptational transformation." What explanation has the Neo-Darwinian theory of evolution to offer for this inconceivably complex and yet harmonious change? It attempts to simplify the problem by separating the true novelties, or mutations, from the processes of adaptation within the organism by means of which, if one organ change, others are brought into harmony with it. It has been shown that many tissues are possessed of plasticity and tend to arrange them-

selves in a developing organism not entirely in a preordained fashion, but also in accordance with certain general principles. The disposition of tendons and the structure of bones, for example, are partly governed by the strains and stresses to which they are subjected during development. In this way the attainment of harmony and mutual adaptation between tissues is simplified. These processes, the result of tendencies inherent in the tissues, are known as functional adaptations. The postulation of functional adaptations enables the biologist to shift a heavy burden from the process of evolution proper, by enormously reducing the number of actual mutations necessary, since so much can be explained in terms of certain simple properties inherent in

the tissues themselves. This appears to be a way of escape from the necessity of postulating an unconcerted yet harmonious change in a large number of separate structures.

We have, however, at present no means of estimating how large a part these adaptations play in evolution. Their usefulness for Neo-Darwinian theory is considerably limited by the fact that though the adaptive properties of tissues are inherited, such particular adaptations as occur in response to a mutation are acquired characteristics and therefore cannot be transmitted. To illustrate this, suppose that the shape of a bone changes as a result of a mutation and that, in consequence, the muscles attached to the bone are modified by means of functional adapta-

tions: Clearly, the changed shape of the bone, being a mutation, would be inherited, but the resulting muscular modifications, being acquired characteristics, would not be inherited, but would have to be acquired afresh by each successive generation. It seems likely that there is a limit to this process, for a succession of mutations leading to considerable changes in the shape of the bone might well put a severe strain on the adaptability of muscles, the inherited disposition of which was quite inappropriate to the new circumstances. As mutations continued to occur, the task of functional adaptation would prove quite impossible. Thus it would seem that functional adaptations are only of limited value in simplifying our ideas

of evolution, unless we are at liberty to suppose they can be inherited. What is the alternative? It is to believe that the harmonious relationships of the different parts of the body are the result of random changes in the various structures. The nice adaptation of all the organs to the upright posture is to be a product of chance. Suitable and unsuitable mutations must be supposed to have occurred in different individuals. Those in which the alterations were inappropriate perished. Only those survived which were fortunate enough to experience an unbroken succession of appropriate changes. A multitude of structures, purely by chance, altered harmoniously in such a way that the delicate and complex machinery of the quadrupedal

animal was converted, running all the time, into the even more complicated machinery of an upright one.

This is difficult enough to believe, but it is not the only strain which Neo-Darwinism imposes upon our credulity. We have been dealing so far with the mode of adaptation of the body to the change from the quadrupedal to the upright posture. We are asked to believe that similar fortuitous mutations are responsible for this change itself. No purely anatomical account can convey an adequate idea of the complexity of the nervous regulation of posture. The work of Magnus has shown that this depends upon the accurate co-ordination of a large number of reflexes. The attitude of the body is controlled

by nervous impulses streaming into the brain from the eyes, the labyrinths, the neck, the skin and the muscles and joints of the limbs. Changes in the position of the body in space, and even of its parts, evoke by means of these nervous impulses appropriate and accurately timed movements. A cat, held in the air and released with its back towards the ground, turns in its fall and lands upon its feet. If a man slip while walking, his arms, without the intervention of consciousness, are involuntarily thrown out in the direction required to shift his centre of gravity so as to re-establish his equilibrium. These are familiar examples of the operation of these complicated postural reflexes. It hardly need be said that the reflexes concerned

in regulating the posture of a quadrupedal animal required profound modification to fit them to perform similar functions in man, who walks upright.

What does Neo-Darwinism require us to believe concerning these changes?

(1) That they are the result of chance alterations in the constitution of packets of chemicals in the germ-cells.

(2) That these chemical changes were purposeless and were in no sense designed to produce the alterations of function which in fact resulted from them.

(3) That they were entirely un-

influenced by the exercise of those functions in previous generations.

(4) That by a series of steps this blind and purposeless chemical instability altered the arrangement of the nerve cells in the brains of certain apes, so that they ceased to progress upon all-fours and stood and walked upright.

(5) That no single step impaired the perfect co-ordination of impulses from innumerable sense organs in eyes, ears, skin, joints, and muscles, whereby posture is regulated.

(6) That, on the contrary, the general effect of the changes, if not of each individually, was to benefit the organism in which they occurred.

(7) That at the same time similar harmonious and appropriate, yet blind and purposeless, changes were occurring in the bones, heart, blood vessels, lungs and other viscera, so that all the organs became suited to the new attitude.

(8) That the appearance of adaptation and design which characterizes these changes is due entirely to the fact that only steps in a certain direction benefited the organisms and led to their selection and survival. All animals undergoing useless or disharmonious changes fell out of the struggle and were lost.

If Neo-Darwinism be true, such a succession of changes must have occurred, not once only, but sufficiently

often to account for the characteristics of all living creatures. What is the probability that this has taken place? Clearly, the more complex a structure is, the less likely are random changes of its parts to result in a harmonious relationship between them. As we shall see, Neo-Darwinism owes much of its plausibility to the fact that it is fundamentally an account of the evolution of form. Its task is facilitated by a spurious simplification. Only if we express the problem in terms of function can we appreciate its full import. For this reason we have considered the evolution of the erect posture. In view of the immense complexity and delicacy of co-ordination of the reflex maintenance of posture, it appears inconceivable that

chance should have successfully effected the evolution of an upright from a quadrupedal attitude. It would be much easier to believe that the time-tables by which the traffic of the railways is regulated are constructed by drawing figures out of a hat.

Neo-Darwinism, then, explains the whole world of life, including the highest achievements of human culture, as the effect of blind mutations selected by a blind environment. If that be true, the lottery, far from being condemned by austere moralists, should be endowed with religious significance as a perfect symbol of the creative process.

Biologists sometimes try to rebut the charge that Neo-Darwinism is materialistic by pointing out that

religion, morality and art are products of the evolutionary process. We are invited to take comfort from the fact that, however irrational the methods of evolution may appear, its direction is leading to the gradual achievement of our ideals. Religion, morality and art, which may be regarded as possessing value apart from their survival value in evolution, do prove of worth also in the struggle for existence. The Universe, therefore, is of such a nature as to encourage the development of these activities, to which we attach value. This argument, however, has the effect, not of idealizing Neo-Darwinism, but of casting doubt upon its adequacy to explain the origin of everything that evolution has brought forth. The Neo-Darwinian assumes

that religion, morality and art can be accounted for by means of the two principles of his theory, germinal mutation and natural selection. No biologist, however, has yet attempted to describe the nature of the chemical change in a gene which has given the world a new religion, a great picture or a moral advance. There is in fact not the slightest evidence that any mental activity can be or ever will be explained in terms of chemical change, or accounted for as a product of such an alteration in the germinal material. The biologist may reply that Neo-Darwinism does not claim to account for all the details of any characteristic in terms of germinal mutation. These, it is held, are the result of interaction of inherited predisposition and environ-

ment. No one expects ever to be able to locate the origin of a heresy in a chromosome. A complex system of theological beliefs, ethical rules, or æsthetic standards is the reaction to a complex environment of an individual with a limited number of inherited instinctive tendencies, which have themselves arisen as mutations at some time in the history of the race and have been preserved through natural selection. But, since all mutations arise in the genes and these are by definition packets of chemicals, this simplified view still requires us to believe that all behaviour can be explained in chemical terms. This belief may justly be called materialistic. If religion, morality and art can be so explained, their existence does

nothing to redeem Neo-Darwinism from the charge of materialism; if they cannot, they imply the presence in nature of some factor of which Neo-Darwinism takes no account.

III

A theory which seeks to explain a very limited set of facts is likely to come into conflict only with other theories which seek to explain the same set of facts. When, however, the facts with which a theory deals are the very stuff of life itself, it will probably be assaulted on two sides. It will be opposed by theories which explain the facts differently and also by theories which explain the Universe differently. The latter form of opposition cannot be dismissed as mere obscurantism except by those

who believe that scientific method is the only mode by which the Universe can be known. Those who object to Neo-Darwinism on the score that it does not explain the facts, maintain that the " simultaneous and harmonious adaptational transformations " required of evolution could not possibly be produced by haphazard mutations in the time available. Those who believe, on religious or other grounds, that the world is the product of an intelligent Creator, find it hard to attribute intelligence to a Power that operates in such a fashion : while those who do not regard behaviour as explicable in chemical terms, cannot accept a theory which traces its origin to chemical changes. For such reasons as these an increasing number of

thoughtful people are beginning to reject Neo-Darwinism in favour of a point of view that may be called Neo-Lamarckian.

Lamarck was born sixty-five years before Charles Darwin, whom he anticipated in a theory of evolution which included the hypothesis that man's posture was developed from one that was ape-like in character. Lamarck believed that the effects of use and disuse were inherited and laid stress upon this as an important factor in evolutionary change. The following quotation from Lamarck's *Philosophie Zoologique* expresses his belief concerning the evolution of man.

> "If any race of primates (quadrumanes) whatever, particularly the more highly evolved of them, were to lose, either from force of circum-

stances or any other cause, the aptitude for tree-climbing and of grasping the branches with their feet, as with their hands, for security of grip; and if the individuals of this race, for a series of generations, be obliged to use their feet only for walking and cease using their hands as feet; then there is no doubt, from the evidence produced in the foregoing chapters, that these apes would finally be transformed into man (bimanes) and that the great toe would no longer be separated from the other toes like a thumb, the feet serving merely the purposes of progression."

Charles Darwin, although he drew attention to other factors, especially the selective action of the environment, or 'natural selection', did not differ from Lamarck concerning the inheritance of the effects of use and

disuse. This is clearly shown by the following passage in *The Descent of Man,* in which he discusses the structural changes involved in the evolution of man's upright posture.

> "As soon as some ancient member in the great series of the Primates came to be less arboreal, owing to a change in its manner of procuring subsistence, or to a change in the surrounding conditions, its habitual mode of progression would have been modified and thus it would be rendered more strictly quadrupedal or bipedal. . . . Man alone has become a biped; and we can, I think, partly see how he has come to assume his erect attitude which forms one of his most conspicuous characters. . . . As the progenitors of man became more and more erect, with their hands more and more modified for prehension and other purposes, with

> their feet and legs at the same time transformed for firm support and progression, endless other changes in structure would have become necessary. The pelvis would have to be broadened, the spine peculiarly curved and the head fixed in an altered position, all which changes have been attained by man. . . . It is very difficult to decide how far these modifications are the result of *natural selection* and how far of *the inherited effects* of the increased use of certain parts, or of the action of one part on another. No doubt these means of change often co-operate."

Darwin, then, was a Lamarckian, and the rejection by biologists of this important element in his theory was one of the doctrinal changes which necessitated the addition to Darwinism of the prefix ' Neo- '.

What account would present-day followers of Lamarck give of the evolution of the human attitude from that of the monkey? Anyone may observe that animals much lower in the evolutionary scale than monkeys from time to time stand upright on their hind legs. The dog and horse are familiar examples of this. They cannot, however, usually maintain this attitude for long, or with any degree of stability. Monkeys habitually sit in an upright attitude on their haunches with their fore-limbs raised from the ground. They presumably inherit the capacity for maintaining an upright posture just as do the horse and the dog, but in monkeys the upright sitting attitude has become much more stable than in most 'lower' animals. It may be

that this is because they have taken to living in trees, for climbing trees necessitates an upright progression. If so, the increased use of an upright attitude, according to Lamarck, would have modified the structure of the body in this direction and these modifications would have been inherited. It is suggestive that another arboreal mammal, the squirrel, is able to maintain a very stable upright sitting posture. The changes in structure, which helped to maintain balance in the upright attitude, in time rendered it possible for the animal not only to sit upright, but also to stand and walk in this position as the gibbon does. This novel use of the legs and feet subjected the whole body to new strains and stresses and so provoked

further modifications which were in turn inherited. Thus there developed the human structure so admirably adapted to the new habits.

This account is at first sight much more plausible than the Neo-Darwinian. It greatly reduces the element of chance in evolution. It explains the harmony existing between different structures in terms of their mutual influence, and justifies a teleological view of functional adaptations. It sees at work in evolution those effects of use and disuse with which we are familiar in everyday life. Why then is it not generally accepted? It is attacked on two main grounds: firstly, that there is no conclusive experimental proof that acquired characteristics are inherited, and, secondly, that no means

are known whereby the germinal material can be influenced by habit.

The former objection raises the question of what is meant by an acquired characteristic. This is usually defined as an effect brought about in an organism by the influence of its environment. Experimenters have, almost without exception, assumed that the only form of acquired character is one which is induced in an organism by some more or less violent interference with it from without. Experiments involving mutilation, exposure to unwonted heat or cold, darkness or light, and the like, have been made in the attempt to demonstrate the inheritance of some resulting modification. Their failure is held to imply that acquired characters are

never inherited. Thus, sixty-nine generations of flies were bred in the dark without producing any alteration in the structure of their eyes. It is difficult to decide which is the more to be admired, the optimism of the investigator, or that of the flies. It is hardly surprising that a germ-plasm which, as Samuel Butler might have put it, has been in the habit of making eyes for millions of years and now does it without thinking, should refuse to be deflected so easily from its usual practice. All that was in fact proved was that no new characteristic was acquired. Even if a new characteristic be acquired and not transmitted, persisting only as long as individuals are exposed to the environment which induced it, what can be deduced from

this as to the possibility of the inheritance of acquired characteristics in the course of evolution? Behind this type of experiment there lurks a tacit assumption that the only way in which a character can be acquired is as a *passive* or *induced* effect of a change in the environment. It is surely possible that there is another method at work in nature which has been overlooked. Some organisms are born changed, some achieve changes, and some, the victims of the experiments in question, have changes thrust upon them. Only an excessive self-confidence, bred of the enormous success of experimental methods, would have led men to believe that the problem of the inheritance of acquired characteristics could be solved once and for

all by their failure to overcome the genetic autonomy of the laboratory animal. Is it inconceivable that a true initiative should exist in nature, and that changes should occur, which are not induced by, but which exploit the environment? Is it not possible that the ancestors of man began to stand upright on their legs, not because their legs suddenly altered, nor because there was a shortage of trees, but because they were pioneers? To suppose that all evolutionary change is the effect either of germinal mutation or of environmental influence is a pure assumption. Only this assumption prevents us from believing that there occurs in nature a novelty of another kind, which is of the spirit that bloweth where it listeth and the manner of

whose coming is known to no man—not even the biologist.

The idea that initiative is a factor of importance in evolution will certainly be contested. It is worth while, therefore, to consider why it is likely to excite objection. Science has no room for the incalculable. Its object is to explain the complex in terms of the more simple. In dealing with the apparently new, it seeks to describe it as a rearrangement of factors previously existing. This mode of simplification was first applied to physics and chemistry, where it proved of the greatest value as a scientific method. It was naturally extended to the subject matter of biology and has illuminated many bio-physical and bio-chemical problems. It is, in fact,

a justifiable and valuable scientific proceeding. Many biologists, however, regard this working hypothesis as though it were the whole truth about biological events. Thus they slip unconsciously from a scientific into a philosophical determinism. Actually, the value of the former in no way implies the truth of the latter. This facile determinist pseudo-philosophy exercises a depressing tyranny over the minds of many laboratory workers. Its origin may be described as by Inadequate Thought out of Scientific Training. To-day it is becoming doubtful whether determinism tells us the whole truth about even physical events. Its inadequacy as the sole mode of describing biological events is illustrated by the geometrical pro-

gression of improbabilities which Neo-Darwinism must postulate in order to account for evolution. Far from science supporting a determinist philosophy, determinism is breaking down through its defectiveness as a scientific method. It need no longer deter us from believing in the existence of initiative.

Superficially more plausible, but at bottom no less naive, is the psychological determinism of the Behaviourists. No one would attempt to belittle the profound physiological and psychological importance of conditioned reflexes. What is to be deprecated, however, is the extension of principles derived from an interpretation of extremely complex and obscure physiological data to the whole realm of human activity. Tennyson declared

that, *if* he could understand the flower in the crannied wall, he would know what God and Man is. No such condition limits the perspicacity of the Behaviourists. Two main principles are regarded as governing animal behaviour: automatic reflex activities with which the animal is equipped at birth, and an equally automatic process of association by means of which these reflexes become capable of evocation or inhibition by many new stimuli. These principles which have been established by experiments on animal reflexes are without hesitation extended to the whole psychical life of man. Automatic modes of activity are familiar enough in human behaviour and have an obvious value. They may even be built up by means of

prolonged conscious effort. To claim that, because such automatisms exist, all behaviour must be automatic, is an assumption which would seem unjustifiable even in the absence of the overwhelming considerations which might be urged against it.

Finally, there may be some who would admit the existence of initiative in man, but who find it difficult to imagine any corresponding activity in lower forms of life. Initiative, however, does not imply either judgment or self-consciousness. If it exist in man, the doctrine of evolutionary continuity seems to require that it should have been derived and developed from a form of spontaneity present in the lower animals. There is much to be said for regarding a simple form of

awareness of the environment and some spontaneity of response as a property of life itself. We have direct awareness of initiative in ourselves. It is, however, incapable of verbal definition, because, being unique, it cannot be expressed in terms of anything else.

If there be such a spontaneous acquisition of new characters in the process of evolution, it would be likely to manifest itself chiefly in the realm of behaviour. Indeed, it is difficult to conceive of an initiative which was primarily concerned with alterations of structure. This is perhaps why so little attention has been paid by biologists to this possible source of novelty. In learning and experiment, on the other hand, lie manifest opportunities for spontaneity and originality,

particularly in experiment with new modes of using the existing bodily structure.

It seems then that the experiments most likely to demonstrate the possible inheritance of ' induced ' characteristics would be attempts to control the behaviour of successive generations of animals. It is therefore of interest that Prof. McDougall is at present investigating the possible inheritance of acquired modes of behaviour in rats.

Initiative, if it be indeed a source of heritable characteristics, is unlikely to manifest itself under experimental conditions. Attempts to compel living organisms to acquire characteristics are methods far removed from those of nature, and it is a strange spontaneity which is evoked by the compulsion

of the experimenter. If characters so induced should fail to be inherited, it would prove nothing concerning the possible inheritance of spontaneously acquired characteristics. The organism that complies against its will may well remain germinally of the same opinion still without prejudice to its ability to transmit a character achieved by its own initiative.

The evidence that we have so far considered in no way disproves that the inheritance of acquired characteristics has played an important part in evolution. Still less should we accept a disproof based upon our ignorance of the means by which the germ-cells could be influenced by bodily changes. Those who emphasize the independence of the germ-plasm usually also proclaim

its immortality. These ideas deserve examination in some detail. The immortality of the germ-plasm, a term first used by Weismann, is maintained with such fervour by some biologists that it appears to be at times a psychological compensation for a loss of faith in the immortality of the soul; for beneath this transcendental name we find an extremely slender basis of fact. It is no doubt true that in some unicellular organisms which reproduce asexually the germ-plasm is potentially immortal. These creatures reproduce themselves by simple division, a process which appears to be capable of indefinite repetition. As soon, however, as sexual reproduction is evolved, it becomes difficult to say to what entity even potential immortality can

be attributed. Before reproduction occurs, the cells which are to give rise to the germ-cells undergo a special form of division. In this, the hereditary material is halved. The new organism is equipped with the full amount by receiving half from each parent. When it in its turn reproduces its kind, this material becomes halved again, and so on at the beginning of each new generation. How much of the original equipment of any individual is likely to be present in his great-great-great-grandchildren? The transmutation of the germ-plasm takes place even more rapidly than that of the stocking in the metaphysical conundrum, which preserved its identity when entirely replaced by darning. Clearly the germ-plasm to which immortality is

attributed is a no more persistent entity than the contents of a glass of water of which half is repeatedly emptied away and replaced from the tap. Even this shadow of immortality is only potential, for in the sterile organism it is never realized. The immortality of the germ-plasm really means little more than the continuity of life.

The idea that the germinal material is largely independent of the body of its bearer is based upon several considerations. In the development of an embryo, the potential germ-cells are early set apart from the rest. Although these cells remain bathed in the same blood-stream as the rest of the body, we know of no mechanism by which elaborate changes could be induced

in the germinal material to mirror the effects of use and disuse upon the body. Further, the independence of the germ-cells appears to be supported by the failure of experiments to induce the inheritance of acquired characteristics. We have already dealt with the last point. The separation of the germ-cells in the course of development would possess no significance if we knew of any mode by which they could be influenced. This is clearly the crux of the problem.

We are on dangerous ground in assuming that something does not happen because we cannot imagine how it happens, especially to-day when knowledge is advancing at an ever-increasing pace. It is during the present generation only that the functions

of the ductless glands have begun to be understood. This study has opened up a vast territory of knowledge concerning every aspect of bodily activity. It has shown especially that small and apparently insignificant organs may exercise a profound and highly specific influence upon remote parts of the body by means of secretions carried in the blood-stream. But we are still far from conceiving any way in which small details of structural change could be mirrored in the germinal material. How, for instance could an increased strain on certain muscles affect a minute part of the chromosome in the nucleus of a germ-cell so as to cause in the offspring a shift in the attachment of those muscles? It may be that some

unexpected development of physiological knowledge will reveal a process by which such a correlation is attained. It is, however, possible that the problem itself is but a product of our mode of thinking and will disappear when we have acquired new biological concepts.

IV

Science deals only with abstractions. Every living individual is unique, and science, to obtain generalizations, must abstract from a group of individuals what is common to all of them. Even the totality of what is common is far too complex for science to handle as a whole, and it must therefore, to achieve simplicity, make yet further abstractions. Two such abstractions of the greatest biological importance are form and function. Form, especially such form as is

visible to the naked eye, is much more easily dealt with than function. Consequently, the study of form has preceded the study of function. The investigation of many functions can hardly begin until physics and chemistry have reached an advanced stage of development. The study of form has a special advantage over the study of function when evolution is under consideration, for form can in suitable conditions be perfectly preserved for æons. Function must perish with the organism of which it forms a part and thereafter can only be deduced from form. It was inevitable therefore, that the idea of evolution should be born of a comparative study of animal forms. Unfortunately, morphology has proved

an over-assiduous mother and has refused to allow her child to be weaned. The results have been far-reaching. The worst consequences might perhaps have been avoided if the rise of evolutionary theory had not happened to coincide with a period of astonishing progress in physics and chemistry and the development of the philosophy of materialism. From the union of a too limited notion of evolution and an unlimited faith in physical chemistry has sprung a progeny of illegitimate ideas to the influence of which no limit can be set. International peace, political stability, religious faith and mental balance have been disintegrated by their malign catalysis.

To see how this happened, it is necessary to consider in some detail

the meaning of form and function. It is not commonly realized how abstract these conceptions are. Nothing at any rate seems more solid and tangible than form, yet it is actually more abstract than function. This is best made clear by an example. Let us consider the circulatory system which comprises the heart, the blood vessels and the blood. To begin with, it is evident that, to give a complete account of the circulatory system, we should have to describe a whole organism. The heart needs nourishment, which is supplied by the digestive system, and oxygen, which is procured by the respiratory apparatus. It is under the control of the nervous system and would soon become poisoned if the kidneys were to fail.

The circulatory system, considered alone, is thus a highly artificial, though convenient, abstraction, cut out of a living organism by our minds. But the process of abstraction goes further.

What do we mean when we use the words 'function' and 'form' in connection with the circulatory system? If we are asked to describe its functions, we shall mention the withdrawal of oxygen from the air and its carriage to the tissues, the removal of carbon dioxide from the tissues to the lungs, the transport of foodstuffs from the digestive system and waste products to the kidneys, and so on. If we are concerned with its form, we shall picture the heart and blood vessels and their structure when viewed through a microscope.

It is not possible here to go into the question of the relationship between form and function, but it will be sufficient to point out a very important difference between them. Function involves duration ; duration has been abstracted from form. This is quite clear in the example we have just considered. The transport of substances in the blood takes time. To give an account of it, we have to describe movements and changes. A description of the state of the circulatory system at a single moment of time would tell us extremely little about its functions. Probably we could not deduce from such a snapshot that the blood circulates at all, a discovery which in fact did not take place until men had been acquain-

ted with the form of the heart and blood vessels for many centuries. If, however, we have to describe the form of the circulatory system, we must remove it from the flow of time. We can do this in imagination by picturing its arrest at some moment of time, or, in actuality, by examining it after death. It is impossible to describe a form which changes. We can only attempt to do so by stringing together a succession of forms each one of which is itself static and unchanging. Form possesses extension in space, but it has been divorced by thought from the flow of time. Function is, therefore, as a conception immensely fuller than form. Although for physiological study we abstract and separate the functions of an organ-

ism, these functions still possess the same dimensions as the whole organism and include duration ; form, however, possesses only extension in space and is thus the poorer by a dimension.

Our minds feel at home in dealing with form. Our habits of thought have been built upon our experience of inanimate objects, the form of which can often for practical purposes be regarded as unchanging We therefore tend to look upon form as reality and function as an elusive activity generated in some way by form. We hold fast to the apparently stable in the changing world of life. We do not recognize that the apparent stability is a construction of our own minds and that in the living organism form is more remote from reality than function.

The whole materialist philosophy subsists on a failure to recognize the abstract nature of form and function. By abstraction from duration the organism is reduced to form, which is dissected into its minutest elements, atoms, or even electrons. It is then supposed that all that is needed to reconstruct the reality of the organism in all its fulness is to picture the atoms and electrons behaving in accordance with the laws with which we are familiar in inorganic objects, and that organic function is nothing more than this. The materialist points to the success of bio-chemistry in dealing with the tissues according to these laws as evidence of the truth of this assumption. It would be as true to say that, because a complete account

of the structure of a cathedral can be given in mechanical terms, we have every hope of being able to explain religion in terms of builders' quantities.

Neo-Darwinism has not yet emancipated itself from this fallacy, with the result that evolution is still regarded fundamentally as a mode of change of form. It is true that we are now beginning to hear of mutations of function, but these seem really to be regarded as, at bottom, changes of form in the germinal material. It is only for the sake of convenience that they are described by their effects, which are changes of function. This morphological approach has had two important consequences. It has oversimplified the problem of evolution. Neo-Darwinism is an answer obtained

by leaving out one factor in the equation. It is a theory of evolution applicable to a three-dimensional abstraction, but inadequate to explain the four-dimensional reality. Secondly, this preoccupation with form has made it unnecessarily difficult to conceive of new functions which are genuine acts of initiative on the part of an organism. All novelties are assumed to be either the result of a change of germinal form or the passive results of reaction to environment. A mechanical conception of evolution has been the result, with a profound influence on our ideas concerning the nature of life and the Universe. Like Galatea, the organism of Neo-Darwinian theory possesses the outward form of life, but obeys the laws of matter. Only a

miracle could transmute its timeless rigidity into the creative activity of living.

Several biological problems appear to take origin from what we may call the Galatean fallacy. Thus, we seem compelled to believe that the chromosomes of the germ-cell, minute structures in an infinitesmal body, can contain in some way the potentialities of the countless characters of a full-grown man. An attempt is made to render this plausible by picturing these potentialities as minute structural elements, though even in this form the idea is hardly conceivable to anyone whose sense of wonder has not been dulled by familiarity. The problem, however, may be a product of our mode of thought. We have seen that

form is an abstraction created by an operation of our minds whereby an organism, or one of its functions, is stripped of duration. It is, nevertheless, true that the study of some functions is less vitiated by such incomplete treatment than is the case with others. For change plays so small a part in some functions that the neglect of the concept of duration hardly affects our apprehension of their nature. A good example of this is afforded by the functions served by bone. After a bone is fully developed, it changes so little during the activities of the organism that we can afford to neglect the element of duration in its function altogether. The bones of the legs support the weight of the body and in this their role is almost

completely passive, or, as we say, mechanical. We do not need to observe them over a long period in order to recognize their function, which is almost equally evident if they are examined after they have been stripped of the muscles and removed for ever from the flow of vital process. Owing little to change, their function almost coincides with their form.

We have already seen that it is otherwise with the circulatory system, the form of which tells us comparatively little of its functions; and there are other functions which appear to depend still less upon extension in space and yet more upon the factor of duration. It seems likely that with greater knowledge we shall be able to arrange functions in an ascending scale in

which duration becomes of ever increasing importance, while the significance of form grows relatively less and less. At the end of the series dominated by form would be placed the functions of protection and support, which we call mechanical, examples of which are the shell of an oyster and the bones of a man. At the other end we might find the functions we call mental and those concerned in the development of the organism from the germ-cell.

Owing to our habits of thought, it is precisely those functions which are expressed mainly in terms of form with which we are most familiar. Hence we find it extremely difficult to conceive of functions in the consideration of which spatial extension

is relatively negligible. It is probably only force of habit which compels us to look for a spatial substratum for every function. This seems necessary because we so frequently become acquainted first with a form, and only later arrive at a knowledge of what we call the function *of* the form. If we realize that form is more abstract than function, we shall find it less difficult to believe that functions may exist to which it is impossible to ascribe correlative forms. The existence of such functions could be deduced, but they would appear to have either no anatomical basis, or an inadequate one. They could be grasped as a whole by the mind, but would resist dissection into duration and form. Possibly we have true awareness of such functions

in the many activities of consciousness, in reference to which spatial terms seem to have no meaning.

It may be of help in understanding the varying dependence of functions upon spatial extension to realize that the arts differ in somewhat the same way in the extent of their debt to form. Sculpture is the apotheosis of form, as the artistic expression of significance; music and poetry, on the other hand, cast the most tenuous of nets around the meanings which they seek to capture. Highly differentiated form may, like the symbols of a primitive alphabet, by reason of its very complexity be unable to express more than very limited ideas, while forms of extreme simplicity, like the dot and dash of the Morse

code, may, in virtue of their arrangement in time, convey the most profound meanings.

I have suggested that the functions concerned in the development of the germ-cell are of the type in which spatial extension plays an insignificant part. In regarding the chromosomes and their constituent genes as containing in some way all that appears to develop from them, we may be no more intelligent than a savage who should look upon the sublimest ideas as contained in the ink upon the printed page. There is a relationship between the two, but it is not a spatial one. This conception does not involve a denial of the relationship between the genes and the corresponding characters of the developed organism. This

relationship is a fact, but a merely morphological or mechanical interpretation of it is inadequate. An analogy may help here. The number on a 'bus does not determine its destination, yet if we want to sort out 'buses according to their destinations, we can do so perfectly by means of their numbers. Perhaps the gene is merely the number on the 'bus. If we could thus regard the genes as simply indicators of functions, no single fact of genetics would be invalidated, and we should be freed from the necessity of supposing that the hereditary characteristics were in any sense located or contained in the germ-cell. Such an idea would be seen to be due to an attempt to employ a mode of thought inappropriate to the aspect of reality

under consideration. The relationship between the germ-cells and the body is also seen in a new light when we regard them as functions instead of as forms. The body and its germ-cells are alike derived from the fertilized germ-cell with which the existence of the organism begins. In the absence of mutations, the germinal material is transmitted unchanged from this cell to the potential germ-cells of the new individual. Nothing is added to it, though the whole of it does not pass to any single germ-cell, since half is lost in the process of maturation. The genes which are present in the germ-cells of an organism do not differ, therefore, from their prototypes from which the body developed. But it is not only the germ-cells of an

organism which embody its original germinal material, the same is true of every cell of its body, all of which are derived from the fertilized germ-cell by a process of repeated division. At each division, the chromosomes and their constituent genes divide, half going to each cell where they grow again to their original size. Thus every cell of the body contains all the genes which were present in the fertilized germ-cell. As Prof. Jennings[1] puts it: "Every cell of the body continues to contain the entire set of parental chemicals, just as the egg did. The differences between the diverse cells of the body are, therefore, not in their substances, not in the genes they

[1] Prometheus, or Biology and the advancement of man H. S. Jennings (Kegan Paul).

contain, but in the remaining part of the cells, the cytoplasm." Embryology furnishes interesting evidence that in the earlier stages of development the fate of any particular cell is far from being determined by its contents. What it becomes appears to depend upon influences entirely external to it. Driesch and other biologists have shown that if an early embryo consisting of two cells be divided in half, each cell, which would normally have given rise to half the body, can form a complete whole. More recently it has been shown that differentiating influences exist in the developing embryo which determine what the cells in their neighbourhood shall become. Cells which usually develop into one tissue, for example skin, may be

induced to form nerve cells by artificially altering their position in relation to the differentiator. This plasticity is lost at a later stage of development. When once the cells have been differentiated, they cannot be further altered. These facts become more explicable in the light of the observation that the whole hereditary material of the organism is transmitted to the nucleus of every cell of its body.

Thus we find (1) that the hereditary material which determines all the characteristics of the organism is present in the chromosomes of the fertilized germ-cell with which its existence begins; (2) that this material is transmitted to every cell of its body; and (3) that the same material is transmitted to its germ-cells by which

it is conveyed to the next generation.

To a mechanistic biology these astonishing facts possess no particular meaning. If we regard the hereditary material as a chemical laboratory, the identity of the genes in the germ-cell and the body cells is of more significance than the resemblance between one crystal of copper sulphate and another. But even if this account of the germ-plasm were true we might well pause in wonder before a laboratory which reproduced itself by repeated accurate division, in which every bottle was halved, and so developed into a vast institute of applied chemistry with many highly specialized departments, each, however, supplied, presumably for old association's sake,

with a cupboard containing a reproduction of the original stock of chemicals

As soon, however, as we escape from this abstract static conception of the organism, and regard the genes as indicators of functions, we can hardly avoid perceiving some part at least of the significance of the facts that have just been outlined. Surely the perpetuation in each cell of the body of the genes of the original germ-cell can only imply a mode by which each cell mirrors the organism, and is functionally under the control of the directing influences which regulate development from the beginning. Further, the fact that the minute nuclear structure of every cell of the body is the same as that of the precursors of the organism's germ-cells renders conceiv-

able the existence of some relation of harmony between soma and germ-plasm and the possibility that the latter may be influenced by alterations in the former. A mechanical interpretation would account for the reproduction of the nuclear structure of the germ-cell in every cell of the body by regarding the cells somewhat as coins struck from the same die, and would see in their spatial discreteness an obstacle to a belief in the existence of any non-mechanical mode of unity among them. A truer conception would regard the similarity of structure as the spatial aspect of a functional unity, much as the activities of thousands of people remote from one another in space may be brought into harmony by the material medium of print, and

the mechanical activity of the printing-press.

It is clear that we are here dealing with relationships which are without parallel in the inorganic world. It should not surprise us, therefore, if conceptions which are serviceable in physics and chemistry are inapplicable to them. It is evident, that new concepts are needed. Biological thought is exhausted by prolonged parthenogenesis and requires fertilization.

V

The Mechanistic philosophy has to its credit the remarkable achievement of having for a century convinced a large proportion of the most thoughtful people that the more you take away from reality, the truer the account you give of it. Everything, if we only knew enough, could be explained in terms of electrons and their movements. Life, mind, art, beauty and religion are thus phantasmagoria, fleeting eddies set up by the electronic dance.

Religion, confronted with this con-

tention and receiving little aid from philosophy, has sought refuge in flight. Psychology, applying the mechanistic method in its own province, has declared all mental processes to be reflex automatisms. By means of the behaviour-reaction known as Behaviourism, it has thus reduced itself to a subdivision of physiology. Psychoanalysis, still dominated by the determinism of Freud, is engaged in adapting men to their environment without considering their adaptation to the universe. Biology, now in the position occupied by physics and chemistry a century ago, is reaping the rich harvest rendered available by the new mechanistic methods in complete confidence that this prosperity will endure indefinitely.

Nevertheless, evidence is accumulating that the tyranny of the Mechanistic philosophy is coming to an end. Like the victims of an epidemic, the departments of thought first attacked are the first to recover; and it is in physics and philosophy that the signs of the change are best discernible. Mechanism has been shaken to its foundations by the discovery that time and matter are not the all-sufficient raw material of the universe, but merely products of the mind's attitude towards the four-dimensional world of point-events. Philosophy, never wholly uncritical of Mechanism, is now groping its way towards the construction of a conceptual system to replace it. This, as the recent work of Prof. Lloyd-Morgan

and General Smuts shows, must be biological in outlook. There are indeed indications that the gulf between life and matter will ultimately be bridged by the application of biological concepts to matter—life's ironic revenge on materialism. The attempt to interpret the highest by the lowest having failed, it now remains to try the reverse process. First, however, it is necessary to recognize the autonomy of the sciences of life and mind. There is hope that, thus emancipated, they will succeed in developing new concepts which may be applicable to other realms of experience. Darwin is the Newton of biology: she still awaits her Einstein.

A philosophic approach to a scientific problem is as important as a so-called

purely scientific method of attack. It is the duty of Philosophy to expose the possible fallacies of unproven scientific hypotheses, which, if accepted unreflectively, may form the basis of a vast edifice of pseudo-science and pseudo-philosophy. I have tried to show in this essay that strict Neo-Darwinism, and the unsatisfactory mechanistic view of the Universe arising from it, rest upon these insecure foundations and that a modified form of Lamarckism can still hold its own as a theory of evolution. It must be emphasized that this Neo-Lamarckism does not dispute the principles of Neo-Darwinism—it merely adds another to them. It recognizes the immense importance of natural selection and the occurrence of mutations as a

result of chance germinal changes, but it denies that this is the whole truth. It would be surprising if random germinal alterations did not occur, and if the germ-cell were the one spot in the Universe not subject to the vagaries of chance. There are many characteristics for which it is difficult to account in any other way, especially the bizarre and the beautiful, which often can hardly be attributed to use or effort. We should expect, too, that other organisms are as capable as man of profiting by good fortune, in other words, that chance mutations have survival value. But it is significant that the great majority of mutations which have been observed under experimental conditions have been pathological. Many would never have

been perpetuated in normal circumstances, but were only saved from extinction by the dysgenic interest of the investigator. Neo-Darwinians freely admit that chance alterations are immensely more likely to damage than to improve the delicate complexity of the germ-plasm. Neo-Lamarckism relegates this blind and random prodigality of mutation to a secondary place in the economy of evolution. It transfers the emphasis from form to function and seeks the main source of novelty in behaviour rather than in chemical change. In this, I believe, it will be supported by the development of new biological concepts more adequate than current modes of thought to deal with the creative activity of life.

THE FUTURE OF DARWINISM

Charles Darwin, like Lamarck, believed that the inheritance of acquired characteristics played an important part in evolution. His followers have rejected this view. Is it rash to believe that the insight of the master led him nearer the truth than their agnosticism has brought his disciples, and that the future of Darwinism is—Darwinism?

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